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ABSTRACT

A review of the literature related to methods for analyzing content or tasks prior to instructional development is presented. The review classifies methods according to a two-dimensional matrix. The first dimension differentiates phases of analysis, each dealing with content and tasks of a particular scope and each generating certain instructionally useful products. The second dimension differentiates between five classes of instructional content, defined in terms of behavior and building on the notion of domains of learning proposed by Gagne. These include: motor skills, verbal information, intellectual skills, cognitive strategies, and attitudes. Following a summary of methods of analysis, an attempt is made to assign methods to positions in the matrix. (Author/MV)

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TECHNICAL REPORT SERIES

TECHNICAL REPORT NO. 2

A REVIEW OF CONTENT AND TASK ANALYSIS METHODOLOGY

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A REVIEW OF CONTENT AND TASK ANALYSIS METHODOLOGY [1]

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ABSTRACT

This paper presents a review of the literature related to methods for analyzing content or tasks prior to instructional development. The review classifies methods according to a two-dimensional matrix. The first dimension differentiates phases of analysis, each dealing with content and tacks of a particular scope and each generating certain instructionally useful products. The second dimension differentiates between five classes of instructional content, defined in terms of behavior and building on the notion of domains of learning proposed by Gagne. Following a summary of methods of analysis, an attempt is made to assign methods to positions in the matrix. The review indicates that the study of analytic methods is an instructional development area of much importance, which is relatively unexplored.

INTRODUCTION

Attempts to systematize and refine the instructional process depends upon the ability to name and isolate the structural units involved in that process.

This paper reviews methods devised to analyze instructional subject matter and to identify within it systematic structural properties related to instructional design. Additionally, it reviews methods of analysis developed in disciplines other than instructional development which appear to have implications for the work of instructional designers.

Educators have been chided in the past, possibly with justification, for attempting to adopt the terminology and form of systems analysis without having an appropriate set of analytic tools and definitions. This paper does not supply such a set, but reviews the work of those who have tried in order to suggest the broad scope of the analysis problem, which to date has received

comparatively little attention. The utility of analysis requires a stability and consistency in the methods evolved to name, manipulate, and relate the properties of subject matters.

Content Analysis and Task Analysis

A distinction should be made between the way "content analysis" is used in this paper and the way it has been used elsewhere. Berelson (1954) wrote on a topic called "content analysis" which aimed at analyzing the impact of mass media communications on an audience, taking into account a broad range of content factors and audience responses. The effects of messages were weighed in that context rather than in instructional terms. Also using the term "content analysis," Grobman (1972) described a process for characterizing textbook content prior to adoption. The variable names in that type of content analysis are more general than those normally used in the work of the instructional developer, since they deal with properties of instructional materials related to style, readability, treatment of sociological issues, and other more global concerns.

Content analysis as it is used in this paper refers to the process of breaking large bodies of subject matter or tasks into smaller and instructionally useful units. Its purpose is: (1) to identify and isolate single idea or skill units for instruction, (2) to act as an objective decision rule for including or excluding topics from instruction, and (3) to provide guidance for sequencing topics in instruction.

Analysis implies a structural view of the instructional process and content analysis shares the goal of the well-known process commonly referred to as "task analysis." Though that term means different things to different developers, it does commonly refer to a process of dividing large task units into small task subunits. The payoff of the analysis process is that each identified subunit is of practical significance to the instructional developer in sequencing instruction or prescribing instructional strategy. Content analysis, as distinct from task analysis, refers to all those procedures which accomplish this division process but which do not necessarily use a single "task"[2] or a "duty" or a "job" as the beginning point for the analysis. Although it is a worthy practical goal for instruction to be designed with an end-purpose in mind, it is not always the case that the end-purposes reduce to a single task or set of tasks.

One of the main theses of this paper is that there are different types of subject matter and behaviors for which it is desirable to develop instruction. All of these types, while they require observable student behaviors, are not "task-oriented" (as "task" is defined in this paper). For instance, some are oriented toward the recall of verbal material, some toward manipulation of conceptual material, and others toward the formation of attitudes. The analysis appropriate to one type of subject matter is not necessarily appropriate for the analysis of all other types of subject matter. Two main types of analysis emerge from the literature reviewed in this paper: analysis for task-oriented content, and analysis for non-task-oriented content. It should be remembered that the use of the term "non-task-oriented" does not imply the irrelevance of observable, measurable behaviors in assessing instructional effectiveness or in designing sequences of instruction. It does mean that such behaviors do not always necessarily build toward a single, comprehensive task performance, but may instead be only loosely related or apparently unrelated.

The terms "subject matter" and "content" will be used interchangeably throughout the paper to refer to a body of tasks, a body of information, or a body of attitudes which the instructional developer expects to be the subject of instruction. This requires that the reader disaffect his thinking about subject matter as simply "history" or "mathematics" and consider that each of these areas are made up of "subject matters" or "content" of all of these types. This point will be emphasized again later.

Background and Purpose

The purpose of this paper is threefold: to identify some terminology and basic assumptions about the analysis process, to suggest a means of classifying analysis methods, and to identify types of analysis which do exist and discuss them in terms of their position in the classification scheme.

The need for methods of analysis has been recognized for over a decade. The most persistent advocate has been Glaser, who over the past twelve years has written of the necessity for identifying structures in subject matter. In an article on programed instruction by Glaser (1962), he stated:

> A problem that arises when one starts to build a programed learning sequence is the analysis of the knowledge domain to be covered. Knowledge must be analyzed into units that can provide building blocks by which the learner goes through an instructional program.

In a later article, Glaser (1964) restated this theme:

> Much more needs to be done on the comparative analysis of the structure of a knowledge domain as it is organized by scholars of that domain, and on the pedagogical structure, required to teach that knowledge; teach it, that is, to optimize retention and transfer. That is a very interesting area in which studies need to be more precisely formulated.

In the paper written at the first of this decade, Glaser (1970) repeated his theme again:

> The properties of a knowledge domain determine the specific character of the student's behavior and, hence, determine the behavior involved in acquiring the information and abilities involved. The content of a body of knowledge, i.e., the ways in which its information is structured and can be processed, must be analyzed, to some extent, before the conditions involved in the acquisition of this knowledge can be studied and implemented.

A number of developers and psychologists have attempted to analyze Glaser's "knowledge domains" in a variety of ways. Their work, however, has not received wide attention, and the attempts to review and compare methods are almost nonexistent (see Chenzoff, 1964, and Smith, 1965). This paper attempts to represent the work on analysis which has been completed to date as exhaustively as possible in hopes of drawing attention to a most important area of development and to suggest a much-needed adjustment in perspectives on the analysis process (see also Gibbons, 1975, for a summary statement).

Discussion will be limited to (1) methods which are presently operational for making a content analysis, and (2) methods which are well enough described to become operational. Some methods of analysis are reviewed here which were not originally intended for use by instructional designers: some arise out of memory research, some out of artificial intelligence research, still others out of linguistics and prose learning research. All of the methods have in common the aim of identifying the structural units of some psychological phenomenon which relates closely to the acquisition of information or skills.

Benefits Derived From Analysis

A number of benefits will accrue to the instructional designer if adequate rules for using analysis methods are devised and tested.

First, communication about the subject matter during design is facilitated if a language has been formed to characterize the elements of content. Not only does communication proceed more efficiently between members of the design and production groups, but negotiations with clients become more structured because it is possible to specify some of the content characteristics of the finished product with greater precision.

Second, it is probable that a language to communicate the properties of content will make the development process itself more efficient and somewhat less costly because of improved, streamlined methods for instructional authoring.

Third, the design of tests and evaluation schemes may be assisted when a careful analysis is made of the elements of content. Often the determination of content elements is based upon some theoretical or research premise. Such is the case in Scandura's work, where a theory of learning results directly in a prescription for analyzing the content of instruction. Implied by the premises is a method for evaluating mastery of the content; hence, the process of analysis creates the foundation for the evaluation. Because most methods of analysis categorize only a few types of behavior, both the production of objectives (an assumed product of any analysis scheme) and tests are facilitated.

Fourth, if units of instructional content can be named and related, then the comparison of instructional programs on the basis of content or skills mastered becomes feasible. It does not appear that such comparisons are possible without a system of analysis. Comparisons in the past, regardless of the stated basis of comparisons, have had some analysis of the content as an implicit factor.

Fifth, given a stable method of analysis, the assignment of instructional strategies may become more a technology and less a subjective process. Taking a structural view of content in the instructional process causes one to consider strategy as the matrix for delivery of content items.

Development projects have already employed many of the methods reviewed in this paper. Careful attention to analysis in day-to-day development practice can pay dividends to the developer.[3]

Structure of the Review

Methods of analysis may be compared on the basis of many different properties, each potentially important. They may be compared by the type of material used as input to the analysis process or by the type of product output by the analysis. Kinds of content may be identified; and methods may be categorized on the basis of the type of content to which they apply, the level of detail with which they deal with the content, or the practical/theoretical postulates on which the method is based.

Certain assumptions are made to structure this literature review. First, it is assumed that instructional content and tasks vary across a set of categories; that there are indeed different types of content or, more correctly, that bodies of content may require different behaviors to demonstrate their mastery, such as verbal behavior, skilled motor manipulation, or demonstration of an attitude. From this assumption comes the corollary that different types of content are likely to require methods of analysis suited to them individually; that one type of analysis is not sufficient to handle all types of content adequately. Another assumption is that, in the analysis of a single body of content/tasks, an instructional developer works through different phases of analysis. He may use a different method of analysis in each of these phases. The output of one procedure under this assumption may be used as the input for the next.

On the basis of these assumptions, a two-way matrix was used to classify the analysis methods reviewed in this paper. One dimension lists the types of instructional content or behavior needed to demonstrate mastery; the other dimension lists the phases of analysis. A discussion of each of these dimensions follows.

Types of Content

An appropriate classification of the "types" of content has been suggested by Gagne (1972). Expanding upon the domains of behavioral objectives identified by Bloom and his co-workers, Gagne suggests a list of domains including (1) motor skills, (2) verbal information, (3) intellectual skills, (4) cognitive strategies, and (5) attitudes.

Gagne's domains are domains of learning rather than domains of behavior or behavioral objectives, and they are differentiated on the principle that each has a unique set of conditions required for learning to take place. According to Gagne, domains of learning help identify those portions of a body of subject matter amenable to different instructional techniques (the setting of different instructional conditions). These domains of learning are adopted in this paper to typify behaviors as they are exhibited toward a given body of content (content types) as well. As Gagne's domains represent types of learning only, using his system as a classification paradigm for types of behavior toward content might not appear appropriate because of the logical similarity between subject matters and disciplines. Gagne (1974), however, stresses that instruction on a single proposition of mathematics may give rise to an intellectual skill in one case or to the learning of verbal information in another. Content itself, in whatever raw form it exists, may not be considered classifiable without considering the behavior the instructional designer intends for his instruction to create. Once the decision has been made, the instructional designer has fated the content to be a part of one of the domains: Verbal Information, if the content is to be manipulated verbally; Intellectual Skill, if the content is to be dealt with in a classification or rule-using fashion. When content is referred to in this paper, it is assumed that it is classified and that the designer who finds himself ready to do content analysis will be able to classify at least roughly whatever propositions, rules, attitudes, concepts, or skills he must instruct under one of the domains of learning which he expects to take place.

Some discussion has taken place on "content analysis" to date, inferring that content actually exists independent of student behavior (Merrill, 1974; Gagne, 1974). If content exists by itself, it must be in the printed and illustrated materials which comprise our corpus of academic knowledge. Content analysis for this kind of content would be a distillation process preserving the essential structure of a mass of content. In short, content analysis would be a shorthand for representing ideas and their interrelations — ideas which are represented in some concrete sense in the words. Though this notion has been considered, it is not sufficient to say that this is the only characteristic of content analysis. The process of content analysis as it is defined for the purposes of this paper includes much more. Structures must be identified not only for verbal information but for skills, attitudes, motor acts, and cognitive strategies as well. These items do not exist in concrete form in print and are not amendable to the distillation paradigm of analysis.

Content for the purposes of this paper results from the combination of a psychological construct and a behavior. It is a product of our own intuition and our understanding of learned human behaviors which we assume require action and some object of action. We invent constructs in content analysis which appear to represent the substance of repetitive human cognitive acts. The behavior which we supply is the behavior we expect to be manifested toward the construct. As constructs for content analysis we may choose concepts, propositions, attitudes, or movements, depending on our view of the cognitive process. Except for propositions, none of these things can be said to exist as such in printed form. Though the concept name and concept examples may exist in some localized area of print, we cannot say that the concept "exists," since a concept

is an artifice invented out of necessity and changed to suit utility. We may not infer existence for a concept outside of the minds of those who possess it. Indeed, in the most searching of our psychological theories, we question whether the same concept is held by any two people exactly alike and whether concepts have any psychological reality at all. With respect to concepts we may specify different behaviors. We may ask for correct identification of exemplars. We may ask for repetition of the definition. We may ask for both. The concept, a construct, is our content. The behavior specified for it is the device by which we assign the concept to a domain so that we may devise instructional strategies to teach it.

Phase of Analysis

A list of phases of analysis is proposed as the second dimension of the matrix. Phases are determined by goals. Analysis during one phase will have a particular design-oriented goal in mind. As a developer enters a new phase of analysis and picks a new analytic tool to use, his purposes change, also. The phases and the goal of each are:

Phase	Goal
1. Gross Analysis	Identifies major tasks, units of verbal information, attitudes, etc.
2. Training Requirements Analysis	Identifies specific learning/instruction requirements for each item identified in phase one above.
3. Instructional Element Analysis	Identifies within-learning-task elements which make up instruction and dictate the structure of single presentations for each item identified in phase two above.

Note that the difference between the first two phases, other than technique used, is the breadth and, potentially, the nature of the unit identified. A single item of the Gross Analysis product would be expected to contain numerous units which require instruction, say a complex of skills or a large unit of Verbal Information. The Training Requirements analysis phase has as its goal to break these comparatively large content/task units into units manageable one at a time in instructional settings. The Instructional Elements Analysis phase identifies within a single unit of content (one item of Verbal Information or one Intellectual Skill) those elements existing which can or should be manipulated during an instructional presentation.

The progression from phase to phase forms a sort of natural sequence for a designer to follow. Although at each phase the general purpose is the same, that is, to make larger content/task units into smaller ones, the implications of the output of each phase are much different. At the Gross Analysis level the units of content resulting would be too large to offer direction for the creation of specific instructional sequences. It is probable that techniques like hierarchical analysis were invented to eliminate the problems, for developer and student both, which arise when this is ignored. From the output of the Training Requirements analysis and Instructional Elements analysis, on the other hand, some very real implications for individual presentation strategies might be expected. From the Training Requirements analysis would come the individual behaviors to be instructed, and from the Instructional Elements analysis would come the actual elements of content to be presented in instruction.

One further phase of analysis was considered for inclusion in this review but was eliminated because (1) specific methods for conducting analysis are not in every case stated but are rather

conceptually described, and (2) the intent of these analyses is not instruction related as clearly as it is politic, economic, and philosophy related. These methods of analysis are aimed at defining educational and instructional goals at the highest level — at the level of originating the need for instruction. Therefore these methods are called methods for Needs Analysis. A few are reviewed here briefly. Those reviewed were selected for their orientation toward specific, orderly methodology or identification of behavior-stated goals.

Coffing and Hutchinson (1974) describe a detailed method for conducting an analysis of needs. They point out the practical demands of this level of analysis and name employers, taxpayers, and educators as the client groups having an interest in the outcome of the analysis. A number of originating disciplines of Needs Analysis methodology are cited, including systems analysis, educational planning, and marketing research.

The needs analysis methodology proposed by Coffing and Hutchinson breaks the total analysis process into ten sub-processes (called sub-purposes in the paper): preparation, contract negotiation, planning, determination of who-what-whom concerns, defining, definition reporting, measuring, measurement reporting, evaluation of needs analysis, and revising. For each of the ten functions in needs analysis, a 12-page flowchart-type description is provided of the process.

No taxonomy or "language" for naming and prioritizing needs is given, which would be the most useful part of a needs analysis methodology. It is the creating of this language which is one of the component tasks of creating a method for analysis. This lack has been perhaps the root of the problem of the analyst for a long time.

Posner and Strike (1974) approach analysis from a structural viewpoint not typical of curriculum workers. They define a curriculum as "a series of intended learning outcomes organized into some structural arrangement." Intended Learning Outcomes (ILO's) are the basic unit of curriculum. They form, according to Posner and Strike, "micro-curriculum elements."

At higher levels, curriculum arrangement is seen to be a study of the various ways in which curriculum elements may be related to each other in instructional practice. Posner and Strike propose a five-division classification system of these curriculum structures. A summary of the classes follows.

In the world-related structure a curriculum is structured in such a way as to reflect the way things "really exist" in the world. An attempt is made to preserve as many of the temporal, spatial, functional, and description properties of the world as possible in the curriculum.

In a concept-related structure, curriculum is arranged in such a way as to preserve the logical consistency of the subject matter. Examples produced of this type of structure are those attempting to preserve the structure of the discipline of the subject matter.

An inquiry-related structure emphasizes the mechanism used to derive knowledge in a discipline. As an example of this, Posner and Strike give Dewey's structuring of teaching based on an analysis of the scientific method.

In a learning theory-related structure analysis is made on the basis of theories of how students learn. In curricula of this type, an attempt is made to conform the subject matter to ideal learning properties as set forth in a learning theory. The analyses of material necessary to prepare a Skinnerian program, or the hierarchical analysis advocated by Gagne, are given as examples of this kind of structure.

In a utilization-related structure the emphasis is on how the learning outcomes are to be used

once they are learned. Examples of this type of structure are those which preserve the order of execution or emphasize curriculum elements on the basis of importance to job execution.

Posner and Strike present their typology as an exhaustive description of the ways in which curricula or parts of curricula are organized. As such, their description of types should permit the instructional developer to conceive a subject matter from a number of structural viewpoints. As an understanding of the effects of structure on instructional design grows, typologies like that of Posner and Strike may produce valuable tools for instructional developers.

A Classification Matrix

The matrix that results from crossing type of content with phases of analysis is illustrated in Figure 1. This matrix is helpful for defining the analyses potentially useful to the instructional designer, given that he can classify his content.

Each cell of the matrix defines the existence of a potential analysis technique or at least a potential analysis need. The remainder of this paper reviews methods of analysis which have been described in the literature and speculates on their assignment to one of the analysis functions defined by the matrix. The structure of the review will be by phases of analysis, since, typically, originators have developed methods specific to a phase and then have attempted to apply them to all forms of content.

METHODS FOR GROSS ANALYSIS

The need to list the major tasks or portions of content as a first step in analysis is almost universally noted in the papers which have been reviewed. Even papers which do not contain techniques of the Gross Analysis type recognize that their starting place is a list of tasks or content which has been produced by some Gross Analysis procedure. Only a few exceptions to this rule, mostly produced during the very early days of instructional technology, are evident.

Miller — Task Analysis for Man-Machine Systems and Training

An analysis described by Miller (1962, 1975) may be applied to two situations: (1) a job already being performed for which training will be developed, and (2) tasks which are only defined as requirements in a man-machine interface and must first be defined as jobs, for which training will then be required. The result of analysis in each case is (1) a listing of tasks to be performed in a single job, and (2) an analysis of each task in behavioral terms. This spans two of the phases of analysis named in the paper: Gross Analysis, and Training Requirements Analysis. Miller calls his two processes "task description" and "task analysis."

Task descriptions for Miller are "the specific statements of all the interactions of man with the system environment." That is, a comprehensive list of tasks which must be performed by men operating the system. Task analysis is "a process whose results provide data about human functions, which (data) in turn are used to determine the characteristics of job aids, training programs, and the assessment of performance of the system and its components." The output of task description, a list of tasks, is the input for task analysis; an example of an interface between analysis phases.

The beginning point of task description is description of the system for which a man-machine interface is being designed. The complete system is broken into a collection of functions necessary in running the system. Each of these functions is in turn broken down into sub-functions in a recursive fashion until finally each sub-function is a "unified, subordinate function which contributes to the total operation of the system;" a single task performed by a worker.

Following the initial listing of tasks in task description, Miller's technique also calls for the description of specific dimensions of behavior within tasks. This calls for stating five items of data about each task: (1) the indicator upon which the task stimulus will appear, (2) the indication which is made, (3) the control object to be activated, (4) the manipulation made on the control, and (5) the indication of response adequacy.

Miller does not specify a definite task analysis procedure, but he offers a conceptual description of the process (see Miller, 1971). He describes a process that could best be termed an "information processing" approach. (Note that his use of this metaphor predates others who more recently have seen its utility. This is an indication of Dr. Miller's strongly independent and pioneering spirit.) It requires identification of the properties of each task as related to a set of basic elements of task structure, small and coherent sequences of behavior which appear as building blocks of more complex behaviors. These elements include reception of task information, retention of task information, interpretation, problem-solving, and motor response mechanisms. As Miller puts it, "Since virtually every task combines in varying proportions all these behaviors,... this constitutes really a task structure rather than a task classification system." We infer that different task structures are defined by the order and the extent to which each task element is called for during task execution. The list of task elements has been expanded somewhat through the years by Miller. For instance, Miller has divided the "problem-solving" element into a list of sub-processes that presumably make up that activity.

P. Merrill — Information Processing Analysis

Paul Merrill (1971, 1974) describes a method of analysis which he calls Information Processing Analysis. A child of the computer age, it is quite similar to Miller's method in principle and similar to other methods described later in practice. The method of analysis involes flowcharting the sequence of operations in a task, indicating decision points or branches. The similarity of this process to Miller's task "flowchart" should be noted. Procedures for obtaining the flowchart are similar to the protocols used by Newell and Simon (1972) in their work identifying problem-solving strategies. Observation is used where it can be, and "thinking aloud" is used where covert (non-directly observable) processes are part of a behavior.

The utility of this method of analysis may be its distinction between hierarchically related skills and order-of-performance related skills. Merrill takes the position that neither hierarchical analysis nor information processing analysis is adequate for all skills which must be analyzed. Information processing analysis and hierarchical analysis may be used to supplement each other. Behaviors important instructionally may be identified using both analyses that would normally be passed over by either alone.

The dependence upon the information processing metaphor and the likening of behavior to computer program execution is a strong current in modern cognitive psychology and artificial intelligence research related to it. A number of analytical methods using some approximation of the metaphor will be found in this review at different points. The temptation to gather them and restructure the review along the lines of the mechanisms of analysis methods was avoided because of substantial differences, applications, and levels of sophistication of analyses calling themselves "information processing" approaches. (However, see Gibbons 1975 where the structure is used). These approaches have received comparatively little recognition as a group as analytic tools for instructional development. It is certain they will become increasingly important and useful as their vocabulary for describing psychological activities becomes more sophisticated, as the method of protocol analysis gains wider acceptance and use in research, and as the methods of analysis demonstrate through research and application their utility in solving instructional problems.

For the purposes of this paper, these methods are reviewed separately. Moreover, they appear in both the Gross Analysis methods section of the paper and the Learning Requirements Analysis methods selection, indicating that the intent and usefulness of these methods is judged to span both phases.

Gard — Information Processing Analysis

Gard (1972) describes a method of analysis which is very similar to P. Merrill's, although he devotes greater attention to the actual process of doing an analysis. Gard states that enabling objectives are in some instances necessarily derived after the information-processing-analysis procedure is completed. The method of doing this is not specified.

The Information Processing Analysis of P. Merrill and Gard are appropriately considered Gross Analysis methods because their output can act as input to other methods of analysis.

Foley — Analysis of Procedural Tasks

The system of Gross Analysis described by Foley (1973) has confined itself to maintenance tasks consisting of more or less invariant stepwise procedures. The current thrust of Foley's work is in the development of Job Performance Aids based on the analysis.

The beginning of Foley's two-step process of analysis is with the indentification of tasks, a Gross Analysis procedure. This consists of observation (interviews, questionnaires, on-site observation, hardware studies) to obtain a list of the tasks performed during a job. The result of observation is a Task Identification Matrix (See Figure 2). The rows of the matrix represent equipment being maintained (e.g., transmitting stations, pieces of equipment within transmitting stations, parts of the equipment, and parts of the parts). The columns of the matrix are defined by a set of thirteen actions which may be applied to the elements in each row. Completing a matrix consists of identifying, out of all possible combinations of equipment and verbs, which actions are to take place on which pieces of equipment. From this matrix is extracted a Task Inventory — a listing, numbering, and naming of each task identified in the matrix. Foley (1973) points up the notions of analysis phases and types of tasks by stating, "The fact that task identification is but the first step in task analysis is emphasized. After tasks are identified, the type of analysis depends upon the purpose for which the analysis is being made. Subsequent steps in the analysis Foley describes apply, we assume, to maintenance tasks specifically.

Following the identification of tasks, a second phase of analysis is entered in which each identified task is analyzed. This calls for the filling out of a second matrix. It is shown in Figure 3. In this matrix, rows represent the tasks from analysis phase one. Columns represent items of information related to the task being analyzed — specific information needed in the performance of the task, the steps in the task, cautions, and special instructions. Auxiliary aids such as diagrams and background data on the equipment are also referenced in these columns. Presumably, the filling out of this table has automatically created a compilation of the material (through selection of material types as headings) necessary for the creation of training materials or job performance aids. The analysis which performs that function would be classified as an Instructional Element Analysis by the definitions in this paper.

Given that the tasks inventoried in the first phase contain a troubleshooting task, one further analysis is required. This consists of stating operational characteristics of the equipment to be troubleshot, along with sequences for carrying out the troubleshooting (called "action trees" and "checkout procedures").

Mager — Goal Analysis

Mager (1972) has devised a method, classified here as a Gross Analysis, aimed at types of content in which goals are normally so broadly and loosely defined that conventional methods of analysis will not serve. The verbs used in such broad goals are suggestive of the Attitude and Verbal Information domains. They are such verbs as "understand," "develop," "internalize," and "appreciate." Though the analysis does not primarily aim to specify an appropriate instructional strategy once it has been completed, the method may be useful as a beginning point for those exploring the possibility of being systematic about the troublesome, difficult to define objectives which exist at the core of many curricula. Mager distinguishes his analysis from four other kinds of analysis which might be undertaken prior to the design of instruction: performance analysis, task analysis, critical incident analysis, and target population analysis.

Mager's process includes five steps. First, the broad goal itself is written down. Next, performances are written down which would be accepted as evidence of goal attainment. Third, duplications are omitted from the list. Fourth, objectives are written for each performance. Finally, the objectives are revised.

Mager's technique is a quick method of operationalizing broad goals on an intuitive basis. Critics will point out that the method is not objective. This is not a strong objection in light of the fact that the alternatives are equally subjective. At the very least, persons using the method outlined by Mager will be forced to think through broad goals. They will also be required to define the behaviors they will accept as evidence of attainment. Mager's method is listed here as a technique for Gross Analysis, though it is appropriately a Training Requirements Analysis method also. The reason for this is that systematic methods of analysis are often accused of leaving out the "really important" objectives of instruction, those dealing with affective responses and general, but unmeasurable (as of yet) skills. This occurs, we assume, more frequently at the general levels of analysis than at the specific. Eventually we would expect the "language" and measurement problems which hinder us now to permit us to be more precise in specifying goals of this type. Until then, Mager's point is well taken that an intuitive method which is acknowledged as such, and systematized where possible, is better than an intuitive method which is not admitted as such.

TRAINING REQUIREMENTS ANALYSIS

Following Gross Analysis and the identification of higher-level and more comprehensive instructional goals, Training Requirements Analysis identifies specific objectives for instruction. The procedures used in the two phases of analysis tend to differ. Writers describing a method of Training Requirements Analysis generally state or imply the need for Gross Analysis prior to use of their method. However, they do not specify the procedure for Gross Analysis to be used, suggesting that it is not simply an extension of their Training Requirements Analysis process.

Ideally, the products of a useful Training Requirements Analysis should have direct implications for the techniques of instruction to be used. In this respect, analytic methods are likely to resemble psychological theories more and more as research and development advance our understanding of the learning process. Ultimately, methods of analysis should deal in units having some clear relation to the mechanisms and procedures of learning. The method of Scandura reviewed in this section is an example of an analysis method based on a theoretical position in which the assumptions about the nature of cognition also imply a certain unit for the analysis process.

Methods of Training Requirements Analysis are of two types: operational analysis methods and taxonomies upon which methods might be based. A review of taxonomies related to instructional design was published by Davis (1973). In that review, taxonomies were classified into six categories (a taxonomy of taxonomies) indicating various approaches which had been taken to

define the elements of learning and behavior. The review covers taxonomies of a cognitive type, but not psychomotor taxonomies like those of Harrow (1972), Simpson (1966, 1970), and E. E. Miller (1972). Krathwohl's taxonomy of the affective domain (Krathwohl, Bloom, and Masia, 1964) should also be noted here, since it is a potential language for analysis in one of the domains. The taxonomies of Gossman and Gilbert alone are reviewed in this paper because additional procedural information is given by those authors on the application of the taxonomy to practical problems.

Gagne — Hierarchical Analysis

Gagne's method of hierarchical analysis is easily the best known of the analytic methods described in this paper. It produces a hierarchy of learning tasks related in such a way that lower order tasks, learned first, produce transfer in the learning of higher order tasks. This is the operational definition of a validated hierarchy. Validated hierarchy production entails two processes : first, construction of a theoretical hierarchy by asking the question recursively "What would a person need to know in order to do this"; second, testing of the hierarchy to see if, in fact, lower order skills produce transfer to higher order skills. The purposes for which the Gagne hierarchy were originally intended are (1) to determine exhaustive training requirements for complex tasks, which eliminates unnecessary topics; and (2) to help determine the order in which instruction ought to proceed by defining sequences of prerequisite skills.

Gagne's methods have found wide-spread use in development, and a body of research was accumulated on the relation of hierarchies to learning. A recent study by White (1974) reviews technical processes in hierarchy building and validation which may account for some of the variation observed in hierarchy studies. His study concluded that although it is possible to validate a hierarchy of tasks, hierarchical analysis is not useful in describing the structures of verbal information relating to instructional sequences. In short, though Intellectual Skills form hierarchies which can be validated, Verbal Information behaviors do not relate to each other hierarchically. Conclusions like this suggest the utility of the distinction Gagne has made between the Verbal Information domain and the Intellectual Skills domain. Work by Gagne (1974) may be interpreted to mean that he expects some elements of hierarchical analysis to apply in domains other than Intellectual Skills. At the same time, Gagne states that hierarchical analysis was devised for analysis in the Intellectual Skills domains, but not for others. Attempts to apply hierarchical analysis outside of that domain are not well publicized, if they exist, and problems such as those encountered by White could be expected. In his 1968 paper on learning hierarchies, Gagne was inclined to separate Intellectual Skills analysis from Verbal Information analysis, although his distinction between domains had not been formalized at that time.

Gagne's work on hierarchical analysis stands out easily as the most widely used and useful single analysis technique in instructional technology. Aside from its tremendous utility in the design of instruction, it has been valuable in establishing that analysis should be used in development to systematize the process and give structure to the product.

Scandura — Rule Analysis

The method of analysis originated by Scandura (Scandura, 1973;Scandura, 1974) is based on a theory of human behavior. Scandura's approach to instructional design attempts to deal with the way behavior is produced rather than in terms of a taxonomy of observable behaviors only. The method of analysis reported in this paper arises out of Scandura's theory of knowledge, the first level of his three-level learning theory. The second two levels of the theory deal with use of the knowledge, first in perfect and then in imperfect cognitive systems.

For Scandura the basic unit of knowledge is the rule, and though there are different types of rules

which have varying effects upon behavior and upon each other, Scandura postulates that behavior can be explained in terms of the execution of rules. Identification of needs and goals is spoken of by Scandura as a beginning point in development, but Scandura does not suggest a technique for deriving them.

Scandura's method of analysis takes place in the following general sequence. First of all, processes (algorithmic sequences) in content are identified (in this case, content appears to be the procedures which are to be performed). The second step involves determining the sub-procedures which make up the total performance and flowcharting the total performance using them as steps. As it is described, Scandura's analysis involves a kind of information processing "walk-through" by the instructional developer, during which the various rules of behavior are determined on an intuitive basis and later confirmed empirically. Note the presence of the information processing metaphor which is central to Scandura's theory.

A strength of Scandura's method of analysis has been in its application to mathematical skills. This method, when applied in instructional development and evaluation situations, has proven to be diagnostically powerful, indicating in most cases the specific rules which are deficient in a student's repertoire. However, it has yet to be demonstrated that Scandura's analysis is useful for less structured subject matter; for instance subject matter in which only verbal information and not specific procedures is learned.

Resnick — Information Processing Analysis

A system of analysis described by Resnick (1973) combines hierarchical analysis as it is described by Gagne with a process akin to the Information Processing Analysis of P. Merrill or the flowcharting of Scandura. Resnick's analysis proceeds by specifying a "chain of component behaviors comprising skilled performance." The result is a hierarchy containing (1) the terminal task at the top, (2) a rank of sequentially related subtasks (the steps in terminal task performance) directly below the terminal task, and (3) a hierarchy of learning tasks below each of those sub-tasks.

The use of this analysis produces both a basis for sequencing tasks in an instructional program and suggestions for special teaching strategies to be used. A body of research on the proposition is beginning to accumulate. The range of application of the analysis is specified as "chains" or "procedure" behavior, and special note is taken of the author's opinion that "verbal knowledge" is not within the domain of behavior analyzable in this way. This is also the conclusion of Gagne relative to his hierarchical analysis.

Pask — Entailment Meshes

Pask (1975, 1974) describes a method of representing the knowledge of a subject matter expert. Pask's mode of representation, called an "entailment mesh," is not meant to represent student knowledge but rather a "permission" structure for him to know. The network, in a somewhat arbitrary way, specifies what knowledge a student may obtain through a tutorial dialogue with a learning environment. The nature of Pask's structures (a difficult thing to understand) is best explained by describing how they are derived.

To begin, a subject matter expert who acts as the resource enters into a natural language dialogue with an interrogator analyst. The interrogator attempts to represent the dialogue content as a set of topics, relations between them, and clusters of relations called relational operators.

During this initial dialogue, the interrogator checks the correctness of his notation by teaching the content he has just received back to the source. If the relational network seems to be correctly

represented, he translates what he has obtained into an "entailment mesh." Mainly, this consists of specifying "bundles" of relations as "nodes" and giving them places as elements in the net. The entailment mesh which results is a hierarchically ordered network founded upon the order of explanation. Ideas (nodes) necessary to the explanation of other ideas in the same mesh are included at lower hierarchy levels.

Once the original network obtained through dialogue has been translated into an entailment mesh, it is tested for cyclicity, (a quality peculiar to Pask's structures). The interrogator/analyst asks the source to name the head node, the top of the mesh "which the source believes to adumbrate the subject matter as it is currently expounded." Here the subjective nature of Pask's meshes is evident. Although detailed rules are given for creating entailment meshes, what seems a very objective process is really a process sensitive to the idiosyncracies of the subject-matter expert.

Pask's method does not attempt to "fit" the content into a task or metaphor framework. Instead, it preserves the framework in which the knowledge is originally presented (including all of its own metaphors) by the subject-matter expert. According to Pask:

> No explicit bounds are placed on the scope of knowledge. For example, the source may exhibit chemistry in textbook terms, in terms of its historical developments, or as the choreography of a ballet of molecules. He can talk of chemistry in any way he likes or in any way he believes a student might think of it; the more the better.... Nor is there any truth requirement. For example, in the subject-matter field of chemistry, the source might describe the phlogiston theory (which is false, but perfectly teachable) or even alchemy (which hangs together in its own fashion.) [p. 21]

A final step called "pruning" puts the entailment mesh into its final form. Pruning is a process of removing redundancy and duplication from the mesh structure. Upon the completion of pruning, Pask describes an important quality of the product thus: "Although the description looks like a hierarchy and thus a taxonomy of nouns, the knowables represented are interlinked relations; knowables form part of a "verb net" not a "noun tree."

Gossman — Categories of Content

The method of analysis proposed by Gossman (1972) is a short-cut analysis based on the assumption of a small number of categories of content. Gossman's technique requires that a set of task requirements for a terminal task be given. The process involves scanning the task four times to find four types of instructional requirements. The first instructional requirement is terminology to be memorized or to be familiarized. On the second pass, new procedures necessary in the execution of the task are identified which are not likely to be in the students' beginning repertoire. The third pass through the task determines decisions which have to be made during task execution. The fourth pass through the task requirements identifies heuristics which are used in the absence of procedures by a person performing the task.

It can be noted that Gossman's method of analysis spans two of the suggested domains of learning, and possibly three. The determination of terminology fits the Verbal Information domain. When procedures are identified, they may be either primarily Motor Skills (e.g., threading a typewriter) or complex cognitive procedures from the Intellectual Skills or Cognitive Strategies domain (e.g., making a complex decision). If there is a problem with Gossman's process, it is that it requires an expert task-performer to decide what goes on during task execution. If the task description is complete enough to reveal this to a novice developer, then the description itself is already a more or less complete analysis document.

Gilbert — Practical Analysis

A better-described analysis along the lines of Gossman's is that of Gilbert (1972). Gilbert's analysis involves not only categories of content into which content is analyzed, but also phases of analysis.

During the first phase of analysis, five activities are completed. First, ideal work "accomplishments" are determined. This is analogous to what is defined elsewhere as task or job analysis, although Gilbert defines "accomplishments" somewhat differently from "task." Second, requirements for each accomplishment are identified. This is the content sorting. For each accomplishment, a process much like Gossman's goes on with similar categories being used. Third, standards (criteria) for each accomplishment are identified. Fourth, mismatches between actual performance and the standards are used to pinpoint training needs. Fifth, the estimated payoff of each identified mismatch is used to prioritize the tasks for training. Gilbert's method clearly assumes no psychological theory as a basis, and is apparently intended for utility in practical business settings.

During phase two of analysis, reasons are identified for deficient behavior on a specific accomplishment, which suggest the scope of instructional approaches to be considered in correcting the deficiencies. Gilbert names five potential reasons for deficiency:

(1.) An employee will be ignorant of consequences.

(2.) An employee has a miscomprehension of company language.

(3.) The employee has no general theory or background.

(4.) The employee has skill deficiencies.

(5.) The local installation has peculiarities which the employee does not understand.

Presumably, the activity of selecting a reason for performance deficiency classes the training problem as mainly motivational, verbal, or skill related. In other words, a domain is selected in which the problem occurs. Gilbert does not give a detailed view of the process which follows this selection nor a theoretical rationale for why it is used. The most interesting characteristics of Gilbert's procedures are (1) the practical, "cut-to-the-core" economic orientation of the method, and (2) the identification of various causes of substandard performance which lead to various types of instructional prescription. Both of these qualities are appealing to the businessmen in industrial development who must justify the expenditure of dollars to their clients.

Mechner — Behavioral Analysis

Mechner's method of analysis, called behavioral analysis (1965, 1967), analyzes knowledge in terms of discriminations, generalizations, and chains, and is one of the earliest techniques reviewed. The stated aim of behavioral analysis is that it "identifies the components of the knowledge or skill to be acquired. Such components are units of knowledge which are introduced one at a time, step by step, and which are sequenced for effective learning when a problem is developed." An analogy is used by Mechner to compare the composition of a molecule with knowledge. He suggests it is appropriate to speak of behavioral "atoms" which exist within a body of content or subject matter. With this analogy, however, goes Mechner's doctrine of variable "atom" size dependent upon target population characteristics. This is treated in discussion below.

Mechner defines discriminations as "making distinctions" or "categorizing" or "classifying." He defines generalization as "seeing similarities in things" or "lumping things together." A discrimination plus a generalization is equal to a concept. The third type of content, a chain, is a "procedure," a "process," "a sequence of actions," or a "thought process." As Mechner says, it is "a sequence of responses where each response creates the stimulus for the next response."

Complete sequences of behavior are analyzed by Mechner into what he calls decision trees. At each node point in the decision tree a concept is present. A response to the concept produces a new stimulus situation which continues the chain of behavior through the decision tree. Each of those node points has a potential number of responses to it and so the chain of possible behaviors continues on, increasing in scope geometrically.

Mechner's discussion of his techniques contains mostly the strategies for teaching chains, generalizations, and discriminations, and not a great deal is said about the mechanics of analysis of content matter down into the component "atoms" (except that Mechner states that the recognition of discriminations, generalizations, and chains requires training). Mechner's work has influenced others in the development of their schemes of analysis, and even though no specific methodology is given in his writings, his work is referred to in this paper because of its pioneering nature.

One additional idea of Mechner's concerning analysis is referred to here because it is a concern of all analysis, particularly at the Instructional Elements Analysis level. His point is that any particular skill or knowledge may be analyzed in many alternative behavioral analyses and that the analyst is responsible for choosing among them based on his knowledge of the target population. Mechner's intent in saying this is to show that for some people the stimulus situation provided by a single concept fills their powers for comprehension, where for others a single concept is too simple, and many other concepts or units of information may be contained within a single stimulus situation without overburdening the learner. When Mechner says that a different analysis may be made, what he means is that a number of units of instructional content may be grouped together depending upon the sophistication of the learner. This notion of a relative rather than an absolute unit of analysis is novel and possibly will be of use in future analysis systems.

E. Smith — Content, Task, and Skill Analysis

A method of analysis described by Smith (Bessemer and Smith, 1972) consists of a number of procedures which produce (1) an analysis of the content properties, (2) an analysis of the tasks to be applied to the content, and (3) an analysis of the skills (information processing) which are involved in executing those tasks. Smith's analysis is based upon a set of five assumptions:

(1.) Any subject matter is unified by a set of interrelated, specialized conceptual systems (which Smith defines).

(2.) Many of the specialized conceptual systems within a discipline share common logical structures and can be categorized by a few types of structural forms.

(3.) Knowledge of a conceptual system and abilities in using that system can be inferred from a defined set of observable behaviors characteristic of that type of conceptual system.

(4.) Common information processing strategies are applicable to the utilization of conceptual systems sharing a common structure.

(5.) Appropriate instruction will produce sizeable transfer across conceptual systems sharing a common structure.

The process of analysis begins with the development of conceptual "systems" — called "analytic concepts" and "systemic concepts." Analytic concepts are frameworks of information which have a consistent structure. They are sets of variables (in the sense of computer programming variables) related together in a single structure — a rigid framework for holding information. Systemic concepts are specified instances of analytic concepts. They are cases in which specific values are given to the variables in the analytic concept. Figure 4 compares analytic and systemic concepts by giving examples.

One analytic concept applied to physics content is the "Variable-Value" analytic concept. In this analytic concept there are four positions (variables) in the framework to be filled: variable name, value, observation/measurement procedure, and elements. In Figure 4, three examples of systemic concepts are given for this analytic concept: force, distance, and time. For each one, a piece of information is supplied for each position in the information structure.

Other systemic concepts might be added; for example, energy and weight. The process of discovering additions to the list would continue until no more were found. At that time, analysis would continue by identifying other analytic concepts in the area of physics. For each of them a full complement of systemic concepts could be identified. Other analytic concepts identified would call for different items of information and would relate the information differently. These other analytic concepts might have structures for defining classes and members of the classes, relating wholes to parts, and relating stages and events to whole processes.

The utility of specifying analytic and systemic concepts and using them to relate all content together into a series of interlocking nets becomes apparent in the second phase of Smith's analysis. In this phase a task analysis takes place unlike the task analysis that developers are most familiar with.[4] Smith's task analysis requires the specification of behaviors which use the content as input and output. Once the task has been specified for one analytic concept, the task applies to each of the systemic concepts which are instances of it. Using the examples of analytic and systemic concepts given on Table 1, a task might be defined for the Variable-Value analytic concept like the following: "Given a variable name (such as weight), and a set of elements (things which had weight), arrange the elements in order according to the order of the named variables." The input for this task is the variable name and set of elements. The output is an arrangement of objects in order of weight, from heaviest to lightest or vice versa. This task would apply not only to the systemic concept for weight, but to those for length and frequency as well. In those cases, the output would be arrangements of objects in order of length and frequency respectively.

For a given analytic concept, the number of tasks which could be defined is enormous. Many of the tasks are trivial and useless, while others are worthwhile and are chosen for training. This choosing begins the third main phase of Smith's analysis — skills analysis.

Skills analysis is the analysis of the information processing involved in the performance of a single task — not necessarily the actual or normal information processing, but one plausible, performable method of processing. Skills, according to Smith's method, are the behavioral building blocks of task performances. During the performance of dissimilar tasks, the same skill might be called upon as a component of both tasks, but at a different time and in a different sequence. It is this quality that gives importance to the products of skills analysis. By determining the skills used as well as the regularities of the content (that is, assigning all like information systems to the same analytic concept), one may proceed with instruction toward two goals at once, each facilitative of the other. One goal is the imparting of knowledge to the student about the physical world (in the case of physics instruction), and the other goal is the imparting of instruction in the use of processing skills enroute to the first goal. Smith theorizes that the teaching of the skills which underlie task performance facilitates the teaching of other tasks which contain the same skills. Smith labels these two types of transfer vertical and lateral transfer, lateral transfer being

the transfer across skill types, and vertical transfer being the transfer toward the main task performance goal. Research completed to date by Smith and others tends to confirm this point.

The type of instructional settings which seem to be particularly in need of the type of analysis described by Smith (and the author feels that at least the third stage of it is very similar to Resnick's method) are those in which critical information-processing skills are in the formative stages (for instance, early-childhood education). In contrast to he widely accepted analytic tools currently used by developers, in which basic skills are (sometimes unjustifiably) assumed to be present, Smith's takes them into account and has devised a method of analysis that identifies them for purposes of instructional developers and makes them subject to manipulation by instruction. Without analytic procedures which identify these heretofore unconsidered dimensions of instruction and of subject matter interactions with student processing, the developer lacks the ability to control at least some dimensions of the instructional materials and sequence them usefully. With strong analytic tools like this one, such control seems possible, and it is assumed that still other very important dimensions of content organization will emerge as developer-usable, as analytic tools continue to be developed.

M. D. Merrill — Content Analysis

A form of analysis described by M. D. Merrill (1973a) called "content analysis" may be used to break down stated problem situations (a high level, but specific behavioral objective) into the concepts and operations a learner will need to learn.

The analysis is based on a set of relational "operations" which can link two or more concepts. This set of operations can help identify a concept in relation to others, or show how a concept (or element of the concept class) is manipulated. A concept by Merrill's definition is a class of objects or events which share certain relevant attributes. Since concepts may be related to each other with the relational operations, and since one concept has the potential of being related to every other concept within a given group, a network is formed which identifies concept class members and demonstrates how they may be manipulated.

The real utility of Merrill's method seems to be that once concepts and relations are isolated they lead directly to prescribed instructional strategy patterns using a system of displays described in the Instructional Elements Analysis section of this paper. A feature of Merrill's analysis is its ability to deal with tasks from the Intellectual Skills Domain (Rules and Concepts) while at the same time representing relations between network elements in a manner much like that used in studies of Verbal Learning. Of particular interest is the specification of a set of relations after the manner of Verbal Learning researchers. Merrill's method of analysis may possess the flexibility of representing both directional task structures and non-directional information structures adequately, and serving as an interface between the Intellectual Skills and Verbal Information domains for analysis.

Smith — Critical Incident Analysis

Smith (1973) describes the use of the critical incident, a simulation of real-life problem-solving situations, in determining training requirements which may not be detected by other analyses. Smith notes that previous descriptions of the use of the critical incident technique have been sketchy and incomplete and attempts to give specific advice on the method of conducting such analyses. Since critical incidents study deficiency of behaviors during performance, we would expect many types of deficient performance to be identified, ranging from faulty attitudes to faulty verbal information and intellectual skills. This method may be used in many domains to identify training requirements as a supplement to other methods. It should be noted that Mager (1972) has also emphasized its importance in identifying training needs.

Shavelson — Measurement of Relatedness

Shavelson (1972, 1974) reports a method of analysis which has been used so far only on an experimental basis. The method consists of a directed graph analysis of prose material to reveal its content structure. Prose materials are converted by a set of rules into numerical relations. The analysis of these relations statistically determines hierarchies of relatedness between concepts. Shavelson has used this method of analysis to conduct research in physics and mathematics instruction. The utility of Shavelson's work is expected to be in the measurement of the conformance of students' cognitive structures of subject matter to the intended instructional communications.

Liu and Pratzner — Association of Terms

A similarly motivated experimental method of analysis described in Liu and Pratzner (1973) proposes to identify concepts possessed by workers performing a job and the structures formed between the concepts. The method consists essentially of three steps. The first step consists of drawing randomly sampled words (concepts) from a pool of technical terms. The second step entails using the sampled words as stimulus words in a controlled word-association task. The third step requires a factor analysis and other statistical manipulations to determine the relatedness of the words to each other. A method of analysis using the same type of word association technique is described by Ammerman (1970) in which hierarchical structures of technical concepts are arrived at by word-association processes. These methods are being developed in the area of technical and vocational instruction.

The benefits of such analysis are assumed to be that identification of the structures of knowledge possessed by workers on the job will contribute to the design of instruction meant to assemble those structures.

INSTRUCTIONAL ELEMENT ANALYSIS

Instructional Element Analysis is closely related to strategy analysis because the analysis products are those elements of the instructional material manipulated by strategy decision rules. Instructional Elements Analysis is a precursor to, but not the same as, strategy prescription. A prescriptive theory of instruction requires the ability to specify in advance the instructional moves or "tactics." Doing this, in turn, requires a definition of the elements to be manipulated by the strategy rules. Though it has been the practice in the past to confuse characteristics of the instructional content with the strategy used for instruction, it appears that progress toward a prescriptive theory of instruction is forcing a distinction between them. It is the purpose of Instructional Elements Analysis to parse bodies of subject matter into these manipulable elements. At our present state of technology, rules for delivering instructional materials to the student are highly intuitive to the greatest number of developers mainly because the rules for strategy and the method of analysis necessary to implement them are yet largely undeveloped. If the emergence of a true technology of instruction is to take place, then strategy rules and the analysis of instructional elements they manipulate must be made explicit for use by technicians, rather than covert and usable only by artisans.

This paper is not concerned with strategy rules. It is concerned with the methods of analysis which pave the way for their use. In this section of the review, those methods of analysis will be covered which have the potential of identifying elements of instructional material which may be delivered to the student at one instant. Caution should be noted against confusing an element of instructional content resulting from the methods reviewed below with the language or visuals in which it is expressed. They are not the same. Instructional elements are those representations of the content which have a completeness according to some definition. The element of content

may require a single word, a sentence, a group of sentences, or a visual representation to fill its definition. If the material being instructed is verbal, the likely units of content will be words in sentences, or perhaps members of a list, or they may represent an idea behind the words whose presence is inferred by the ability to state or paraphrase the idea or its extension. If the instruction seeks to establish higher cognitive skills like classification or rule-using, the unit of content is likely to be called "example" or "definition." Examples and definitions may be one sentence or, in some cases, many pages long. The analysis methods described below are methods which specify elements of content within each of the domains of learning.

Crothers, Frederiksen, Johnson, Meyer, and McConkie — Language Research

In language research a number of methods of analysis have been devised which are potentially useful to instructional designers working at the Instructional Elements level of analysis. These methods of analysis have been adopted to study the effect of structural properties of prose passages on human memory. One approach has been to analyze the explicit and/or implied semantic relationships in a prose passage. Crothers (1972, 1975a, 1975b) and Frederiksen (undated) are examples of this approach. Crothers' method of analysis breaks a prose passage down into words which are united by a number of semantic relations, some explicit in the paragraph, some only implied. Frederiksen's method of analysis is quite similar. In it, the relations used are a different set, the size of the verbal unit taken as basic is very often longer than a single word, and only explicit relations are analyzed.

Johnson (1970) and Meyer and McConkie (1973) have studied the structural properties of paragraphs by dividing them into phrases or other defined units composed of adjacent words. These units and their relationships to each other have been demonstrated to have a direct relation to recallability of a prose passage. Since a great deal of instruction takes place in the verbal information domain, these analyses may be useful to developers in the future. In particular, the elemental units which have been invented for analysis, and the relationships between them may be turned from analytic tools for parsing passages to a prescriptive tool for constructing them.

Anderson — Analysis of Instructional Text

O. Roger Anderson (1974), in his work with the teaching of biological subjects, invented a method for charting the strategy of a presentation. Of necessity, such a technique is based upon a taxonomy of the content items which can be delivered to the student. In Anderson's method the items of the taxonomy tend to be words or phrases embedded within the sentences used in instruction (this could be verbal or written). By showing the relation of these items to each other as they appear in instructional presentations, Anderson is able to derive a number of indices related to instructional strategy. In form, the analysis is much like that of the language researchers.

Carbonell and Wexler — Artificial Intelligence and Instruction

Another field which shows some promise in producing methods of analysis useful for the instructional designer is artificial intelligence. The work of Carbonell and Wexler, though dealing with instruction, arises from artificial intelligence. Carbonell and Wexler have based their systems of analysis on the assumption that verbal information may be represented as a network and that the network may be used as a device within a computer for generating instructional sequences.

Carbonell's method of analysis was used in an experimental Computer-Assisted Instruction system called SCHOLAR (Carbonell, 1970). In this system, information to be learned by the student is entered as a semantic network, structured after the work of Collins and Quillian (1969). From this base, either machine-controlled sequences or student-controlled sequences of instruction may be constructed by an executive program. The instruction given by the SCHOLAR system is carried out in a tutorial dialogue and attempts mainly to impart factual information. Appropriately

enough, the network consists of nodes, which represent words, and relations which represent a set of semantic relations between them. The semantic net is the base out of which verbal instructional statements are generated.

A system invented by Wexler (1970) uses essentially the same philosophy with some variations. Wexler describes the mechanism underlying his system as follows:

> An analogy may be drawn between the material prepared for a typical CAI course and a spider web or directed graph. The information statements or questions correspond to the nodes of the web or graph and the links between nodes correspond to anticipated responses, particular past histories, etc. The computer then acts as little more than a simple pointer when it traces a path through this material, even though each student may follow a different path through the subject [p. 181].

For Verbal Information instruction, the work of Carbonell and Wexler demonstrates the application of a technique for analyzing the entity to be learned, the proposition, into the components which will be manipulated during instruction (nodes and relations).

Others in the artificial intelligence field have attempted to identify the structural properties of communications, problems, situations, and spatial arrangements and may provide techniques which are potentially useful to the instructional designer (c.f., the Proceedings of the Third Joint Conference on Artificial Intelligence, 1973). Reference is not made to each of them because they are numerous and are more distant to immediate utility than the methods reviewed here.

Scandura — Rule Analysis

Scandura's analysis method, already described, is mentioned here as a method of detailed analysis because of the theory base upon which Scandura places his analysis. Behavior for Scandura is rule-generated. Scandura makes the point that one deficiency in the behavioral objectives approach to instructional development is that once objectives are written there is no indication of the content of the behaviors required. Objectives only state that a behavior is to be executed under certain conditions to a certain standard. No details on the method or procedures for behavior execution are given in an objective. Identifying the rules executed with rule analysis, on the other hand, provides the developer with all of the necessary elements with which to proceed in specifying the sequence and formatting variables attendant to instructional strategy.

Evans, Glaser, and Homme — The RULEG System

Evans, Glaser, and Homme (1960) described a system for categorizing programmed instruction frames (in Skinner/Holland-type programs). The elements manipulated within a frame were "rules" and "examples." Examples are defined as more specific versions of rules. The RULEG system was useful to programmers as a notational device for charting instructional strategies.

A significant weakness of the RULEG system was stated by Evans, Glaser, and Homme thus: "We have not yet discovered a completely satisfactory definition of a Ru, nor are we convinced at this stage that we need one." Despite the confidence that a definition of a Ru was not necessary, the device lacked power and specificity in application. At the same time, a proposition serving as a Ru might be an Eg to some other Ru as well. Although the technique of the RULEG system supplied a method for attaining relative structure within a program, its variable nature deprived it of some of its usefulness.

M. D. Merrill — Instructional Display Types

M. D. Merrill (Merrill, 1973b; Merrill and Wood, 1974) specifies a set of content items bearing

strong resemblance to the RULEG system but having an additional mechanism for standardizing the properties of both Ru and Eg, thus making more specific their meaning and use.

Merrill suggests the use of a device called an instructional display. The function of instructional displays is characterized in terms of Content and Form: a display may have two types of content — Generality (analogous to the Ru), and Instance (analogous to the Eg), and it may also appear in one of two forms — Inquisitory or Expository. Figure 5 shows that by crossing the Content and Form dimensions, four conditions are obtained: Expository Generality, the statement of a rule or definition; Expository Instance, the presentation of an example; Inquisitory Generality, asking for the rule to be stated; and Inquisitory Instance, asking for an instance to be classified, solved, supplied, etc.

The Form and Content qualities of a display as given by Merrill are only a little improvement over the RULEG system, particularly the involved notational variations of the RULEG system used for stating the responses expected from the student during a frame, and for presenting various numbers of Ru's and Eg's in different states of completeness. Merrill, however, gains much specificity by combining the notion of display types with a taxonomy of behavior types. As instruction proceeds, it proceeds within one of the behavior-type categories, (Memorization, Classification, Rule-Using), and therefore the meaning of Generality (Ru) and Instance (Eg) become much more definite. The Generality for a Rule-Using lesson is the rule itself. For a Classification lesson it is the definition of the concept, and for a Memorization lesson, it is the specific thing to be memorized. Instance takes on the same specificity relative to the Generality, and relative to the behavior. For Classification behavior, the instance becomes an instance of the class. For Rule-Using behavior, the instance becomes a demonstration of correct application of the rule.

When applied to actual instructional development practice, the notion of defining display types within lesson (or behavior) types simplifies the stating of instructional strategies tremendously and provides a prescriptive technique for writing effective instruction. This technique for instructional development has been employed in the design of the TICCIT Computer-Assisted Instruction System (Bunderson, 1973), and other non-CAI applications within and without Courseware, Inc. (cf. Christensen & Gibbons, 1974).

Horn

Horn (Horn, et. al., undated; Horn, et. al., 1971) has devised a method for dividing the explanatory materials usually found in instruction into "blocks" of information in a process called Information Mapping. Originally devised as the mechanism for a computer-based learning and reference system, the process breaks instructional prose and diagrams into sections which tend to have a single instructional intent, that is, which seem to be carrying a single message of some instructional type. The result of information mapping is "a flexible (computer) data base, organized into labelled, movable information blocks according to the principles of information mapping — a system for categorizing and displaying information." To quote Horn further: "One of the most important requirements of Information Mapping is that every sentence and illustration in a subject matter must be a part of an information block." Information blocks are combined into information maps by conglomeration in which the blocks do not lose their identity.

Rules are specified for the writing of each type of block. Seven varieties of information map are listed by Horn: concepts, structures, processes, procedures, classifications, facts, and proofs. Within each of these map types, certain information block types are specified to carry the instructional message. Within the concepts type of map, the following block types are listed: name of the concept, definition of description, theorem (or generalization), formula, use, rule, example, non-example, introduction, synonym, notation, diagram, comment, analogy, and related maps. For different map types, different block types which make them up are specified.

Horn's information maps are similar in mechanism to Smith's analytic concepts and Merrill's display types. Upon encountering systems such as these, the immediate question of importance is, "What foundation of research or theory is there for this method?" Smith is conducting research into the utility of his analyses in promoting vertical and lateral transfer. Merrill's prescribed display presentation rules for concept instruction are based on a body of research, and other research can be used to provide a prescription for the use of display types in memory and rule-using instruction. Horn's information mapping, though extremely simple to use and enjoying some popularity in industrial training, lacks the base of direct research possessed by the other two. Continued use of this method over time should spur the sort of inquiry that would increase the precision with which it could be used.

B. O. Smith — The Logic of Teaching

Smith and his associates (Smith & Meux, 1970) have approached the question of a taxonomy of instructional presentation elements through the device of instructional "episodes," verbal exchanges between student and teacher. Called a study of the "logic" of teaching, this work attempts to categorize episodes under one of thirteen headings. Episodes are defined as "a unit of discourse beginning with an expression which triggers verbal exchange about a topic and ending with a completion of the discussion on that topic." The types of episodes identified by Smith and his associates include: defining, describing, designating, stating, reporting, substituting, evaluating, opening, classifying, comparing and contrasting, conditional inferring, explaining, and directing and managing. Under the explaining category, six different types of explaining are named: mechanical explaining, casual explaining, sequent explaining, procedural explaining, teleological explaining, and normative explaining. Actual classroom dialogs are analyzed by Smith and his co-workers to test the adequacy of his classification system.

Smith's work is aimed at specifying the variables inherent in classroom teaching. As well as suggesting a useful analysis mechanism, he states the justification of his study which echoes the philosophy of the present paper as well.

> ...studies of teaching have been carried on as though the phenomenon of teaching were well understood. For example, there have been investigations of the attitudes of teachers towards their students; studies of permissive and authoritarian behavior of teachers and the effects of such behavior; studies of the intelligence of teachers and their knowledge of the subject-matter; and inquiries into their personality traits. The failure of such studies to yield a body of consistent knowledge about instruction indicates that perhaps they were premature; that more direct or primitive analyses of teaching behavior are needed as a preface to experimental or correlational studies. Furthermore, such factors as personality traits, intelligence, and knowledge of instructional content are static elements of teaching behavior, indicatng nothing about the operations involved in teaching, that is, how concepts, norms, laws, etc., are introduced, analyzed, and manipulated in the course of instruction.

CONCLUSION

Some conclusions and summaries are appropriate at this point. The main conclusion is that the range of techniques available for analysis to the instructional developer is only beginning to be explored. Isolated methods of analysis have been developed for applications in various disciplines, but attempts have generally not been made by independent workers to compare or combine analyses. Few studies were found which discussed relative merits of analysis methods on similar problems, or noted that different approaches to analysis existed. On the contrary, developers of analyses tend not to mention other methods of analysis, with very few exceptions, as if they did not exist at all.

Just the opposite is needed. The full range of analytic techniques from which the developer may select needs to be inspected. The works presented in this review indicate that analysis is a multi-phased process which can be used to facilitate the design of instructional materials. This author feels that a longer analysis phase shortens the production phase by structuring the content to be manipulated more usefully. Note, for instance, the prescriptions for instructional strategy made possible by Merrill's use of display types. It is appropriate to consider the analysis techniques available to the designer as a kit of tools — each meant for a particular purpose, each maximally useful only for its intended application. In the real world, one tool is seldom enough for a job. Neither are all of a workman's tools required for every job. Perhaps when this perspective of analytic technique becomes common among developers, the words "design" and "systematic" will come to be more rich in meaning and another element of guesswork will be eliminated.

A reference matrix was constructed in the initial sections of this paper for categorizing analytic techniques. Figure 6 attempts to place techniques on the matrix. Consideration was given to authors' statements of the intent of their analyses, a study of the actual mechanisms of the analyses, and conjecture on the part of the reviewer. Nothing absolute or final is meant by this filled-in matrix. The process of posting methods within the matrix has reminded the reviewer of its temporary nature. Many decisions were difficult to make because methods did not fit neatly into categories and phases.

Even with the problems inherent in a simplistic matrix like the present one, some useful and interesting patterns may be detected. The most apparent is the absence of analytic techniques in the domains of Attitude and Motor Skills instruction. The application of analytic techniques has produced numerous hierarchies and sets of objectives for the common school subjects of the Intellectual Skill type (Mathematics, Science, English) and analysis techniques abound in those categories. This is not true of the Motor Skills area, nor of areas that are heavily loaded with affective, rather than intellectual responses. The same applies to a lesser degree with Cognitive Strategies, though in recent years, much analysis has been developing in this area.

The reader may be inclined to ask where the study of analysis methods leads. The reviewer is inclined to offer an extrapolation from the past. Tyler emphasized the importance of using instructional objectives. Bloom (1956) suggested that all objectives were not the same, and Gagne agreed and suggested a way to categorize them, as had Bloom. More important, Gagne suggested a method for deriving training requirements for using his categorization of objectives as a part of the mechanism. This paper suggests that analytic techniques — the processes which produce objectives — can also be classified. As our description of the units of instructional specie has become more sophisticated, the next logical step seems to be to identify the scope of the possibilities and begin to identify local landmarks.

Then the philosophy may become common that a combination of analysis techniques might be necessary to achieve what Macdonald-Ross (1973, 1974) refers to as the best "representation" — the most economical, useful notational system which preserves in instructionally usable form as

many of the characteristics of the content as possible. The search for such a system will surely take into account the notion of the psychological structure of the content as in Minsky (1974) and Norman (Norman, Gentern, and Stevens, in press). Then, as our concern with representation of content matures, our study of the strategies by which we instruct will be broader and more fruitful.

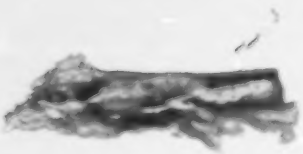
FOOTNOTES

1 Portions of this paper were presented at the annual meeting of the American Educational Research Association, Chicago, Illinois, April, 1974. The author is indebted to the following persons for their advice and interest in the preparation of this paper: M. D. Merrill for encouragement and editorial review; Jonah P. Hymes for editorial review; John Carter, John Ellis, and Dexter Fletcher for critical comment on the classification scheme; and Renata Schmitt for a careful editorial review.

2 The word "task" in this paper may create confusion if it is not defined. "Task" refers to an algorithmic behavior with a beginning, sequence, and end, normally executed by a competent performer. The end product of many instructional development projects is meant to train a student to perform a body of tasks—often in a certain way and in a certain order, such as flying airplanes or troubleshooting equipment.

3 A few projects known to the author which have experienced the impact of analysis in the ways stated above are: The Statistics 221 Project (Christensen & Gibbons, 1974; Gibbons, 1973); the TICCIT Project (Bunderson, 1973); and Scandura's projects in mathematics (Scandura et al, 1971). There are other projects currently underway in which careful analysis and the use of its attendant economics is reducing the development or evaluation burden or making instruction more effective as evidenced by small-scale tryouts.

4 It is perhaps a reflection of the state-of-the-art in analysis for development purposes that a number of authors reviewed in this paper affixed the title "task analysis" to the methods they described. Miller's process of task analysis focuses on one aspect of tasks, Foley's description of a task analysis procedure focuses on a completely different one. Many have fallen into the habit of calling Gagne's learning hierarchies task analyses and those advocating a flowcharting of performances for analysis purposes (cf. P. Merrill, Resnick, Scandura, and others) have used the term "task analysis" to apply to what they do.



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DOMAIN / PHASE	Motor Skills	Verbal Information	Intellectual Skills	Cognitive Strategies	Attitudes
Cross Analysis					
Training Requirements Analysis					
Instructional Element Analysis					

FIGURE 1. A MATRIX FOR THE CLASSIFICATION OF ANALYSIS METHODS

SYSTEM HARDWARE LEVELS \ MAINTENANCE FUNCTIONS	1 Adjust	2 Align	3 Calibrate	4 Checkout	. . . . .	13 Troubleshoot
12. Landing gear subsystem						
. . .						
13. Communication subsystem	O	O	O	TL		O
13.1 Transmitting station	O	O	O	TL		O
13.1.1 Modulation equipment	O	O	O	TL		T
13.1.1.0.1 Power supply	O	O	O	TH		O
13.1.1.0.2 Mod unit	O	O	O	O		O
13.1.1.0.2.1 Speech amp	O	O	O	O		T
13.1.1.0.2.2 FSK	O	O	O	O		T
13.1.2 Transmitting set	O	O	O	T		O
13.1.2.1 Transmitter	O	T	O	O		O
13.1.2.1.1 Osc	T	O	O	O		T
13.1.2.1.1.1 SMO	T	O	O	O		O

FIGURE 2. A SAMPLE TASK IDENTIFICATION MATRIX
(After Foley, 1973)

Task Analysis _____ Page No. _____

TASK DESCRIPTION / CONTENT CATEGORIES / TASK INVENTORY / TASK STATEMENTS & CODES	A Equipment Description & Operation	B Equipment Drawings	C Equipment Configuration Applicability	. . . . .	M Notes

FIGURE 3. A SAMPLE TASK DESCRIPTION INDEX AND MANAGEMENT MATRIX
(After Foley, 1973)

ANALYTIC CONCEPTS	SYSTEMIC EXAMPLES		
variable name	force	distance	time
values	n pounds	n feet	n seconds
observation/measurement procedures	use of spring scales	use of foot ruler	use of 1 second pendulum
elements	physical bodies	physical bodies	physical bodies

FIGURE 4. ANALYTIC AND SYSTEMIC CONCEPTS
(After Smith, 1974)

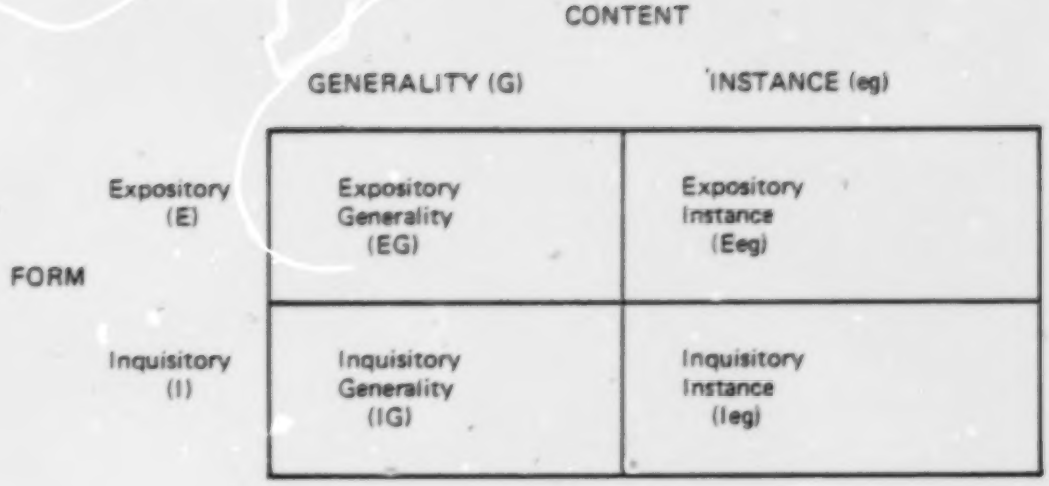

FIGURE 5. BASIC DISPLAY TYPES
(After Merrill, 1973)

	MOTOR SKILLS	VERBAL INFORMATION	INTELLECTUAL SKILLS	COGNITIVE STRATEGIES	ATTITUDES
GROSS ANALYSIS		Mager Gilbert M. Smith	Miller P. Merrill, Gard Resnick Scandura M. D. Merrill E. Smith M. Smith	P. Merrill, Gard Mager Resnick Scandura E. Smith M. Smith	Mager M. Smith
TRAINING REQUIREMENTS ANALYSIS PHASE		P. Merrill, Gard Mager Resnick Pask Gossman Gilbert E. Smith Shavelson E. Smith M. Smith Liu, Pratzner	P. Merrill, Gard Resnick Gagne Scandura Pask Gossman Gilbert Mechner M. D. Merrill E. Smith M. Smith	P. Merrill, Gard Resnick Mager Scandura Gossman Gilbert E. Smith M. Smith	Mager Gilbert M. Smith
INSTRUCTIONAL ELEMENTS ANALYSIS PHASE		E. Smith Horn Crothers O. Smith Frederikson Johnson Meyer Carbonell Wexler Evans, Glaser, Homme	M. D. Merrill E. Smith Horn O. Smith	E. Smith Evans, Glaser, Homme Horn	M. Smith Horn O. Smith

FIGURE 6. FILLED-IN ANALYSIS MATRIX